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DEVELOPMENT OF AN OCCUPATIONAL STRENGTH TEST BATTERY (STB).(U)
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DEVELOPMENT OF AN OCCUPATIONAL STRENGTH TEST BATTERY (STB)

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A strength test battery (STB) was developed to predict performance on Navy job tasks with substantial muscular demands. The STB includes 14 tests representing four strength factors--static, dynamic, power, and anthropometric. The STB was administered to men and women recruits and evaluated for battery administration time, differences in men's and women's scores, relationship between strength and body weight, sensitivity of the STB to measure changes resulting from physical conditioning, and the tests' validity and reliability.

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Results indicated that the STB provides a safe, quick, inexpensive method for measuring an applicant's strength capability and for monitoring strength and body weight changes that result from physical conditioning activities. The STB should be evaluated further for occupational classification purposes.

FOREWORD

This project was initiated in response to a request from the Commander, Naval Military Personnel Command (NMPC-5--Occupational Classification Department) to develop physical standards "to allow the Navy the best choice of personnel assignment in a time of access to a decreasing manpower pool." The objectives of the project are to (1) develop a strength test battery (STB) to predict how capable personnel will perform muscularly demanding (M-D) job tasks, (2) identify the most M-D tasks of Navy shipboard duties and job specialties, and (3) determine the percentages of men and women capable of performing those tasks. The work is in support of the Navy Affirmative Action Plan (FY82), Objective U-1: "To ensure appropriate utilization of personnel resources, develop strength and stamina indices for physically demanding Navy billets . . . . (that) preclude gender-based decision making."

Although projects to develop predictive test batteries typically start by measuring the critical job task for the criterion behavior (objective 2 above), objectives (1) and (2) were initiated concurrently for three reasons. First, a single, generalizable STB must be applied to a great variety of job tasks among a large number of Navy shipboard duties and job specialties. Second, STB base rate data are needed to determine the impact of cut-scores (i.e., percentages of men and women excluded from entering each job specialty) as each criterion task is selected and administered as a M-D performance test. Third, there was considerable basic research on physical fitness factors that was useful for identifying tests and procedures for the STB, thereby facilitating immediate progress on that objective. By contrast, since there is little basic research on methods to identify and test the critical aspects of M-D job tasks, progress towards objective (2) is slower.

This report describes the part of the work addressed to the first objective--development of the STB. Subsequent reports will describe the procedures used to document and administer performance tests of M-D tasks and demonstrations of the STB's validity to predict performance on those tasks. There are several fundamental issues that are yet to be addressed, including the site at which to administer the STB (e.g., recruit processing or recruit training centers) and adjustment of cut-scores for strength gains/losses from existing or lacking physical conditioning activities. These matters will be reported as data are collected and decisions made by management.

Appreciation is expressed to CDR Gloria Holmes (NMPC-5) and many members of the staff of the Naval Occupational Development and Analysis Center for their assistance in administering the STB to recruits.

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SUMMARY

Problem

Although many Navy tasks appear to require substantial muscular capability, occupational strength and stamina standards are not presently available for them. Without these standards, and without means for measuring the ability of men and women to perform to the standards, personnel may be assigned to billets in which they cannot fully perform all tasks. A particular problem for the Navy is that sea duty assignments may involve tasks that demand more strength than do the specific technical specialties to which personnel have been assigned.

Purpose

The purpose of this project was to develop a basic strength test battery (STB) to predict performance on Navy jobs that require strength.

Method

Fourteen tests--eight strength tests representing three strength factors (static strength, dynamic strength, and power) and six anthropometric measures--were included in the STB. The static strength tests, which were measured by dynamometers, were handgrip, arm-pull, and arm-lift. The dynamic strength tests were of the calisthenics type: sit-up, push-up, pull-up, and bent-arm hang. For a measure of upper torso power, a hand-cranked ergometer was used to simulate job tasks that involve a turning or pumping activity. The anthropometric measures were height, weight and skinfold measures at four sites--triceps, subscapular, abdomen, and thigh. In addition to the 14 tests in the STB, additional scores were derived from the anthropometric measures: lean body weight, fat body weight, percent body fat, weight-to-height ratio, and fat body weight to lean body weight.

The STB was administered at the Recruit Training Center, Orlando, Florida, to a sample of about 400 men and 250 women at the beginning and end of their recruit training. To compare differences between men's and women's scores, a ratio of means and the Tilton percentage overlap were used. Because strength and weight gains and losses occurred in opposite directions for high- and low-scoring groups, these groups were analyzed separately.

Results

1. Testing time to administer the 14 tests in the STB was about 12 minutes per person. The tests used readily available equipment and their administration required no special training.

2. Generally, there was little overlap in the distributions of men's and women's strength scores: Only the highest women's scores overlapped the lowest men's scores. The greatest overlap was on the sit-up (49 percent); and the least, on handgrip and arm-pull (12 percent).

3. The various body weight measures, including total weight and percent body fat, correlated positively with static strength and power and negatively with dynamic strength.

4. Several of the strength and body weight tests were predictive of a simulated job task involving cranking or pumping activities. Using the ergometer as the simulator of this kind of task, the best predictor for men was lean body weight ($r = .45$) and for women, arm-pull ($r = .36$).

5. The tests for which test-retest data were obtained, the static strength and skinfold measures, were found to be quite stable, with reliabilities mostly in the .90s. For the assessment of body fat or overweight, the skinfold measures were found to be more useful, particularly in monitoring changes, than was the proportion of weight to height.

6. When the STB was used to track changes resulting from the recruit training conditioning program:

a. The largest relative gain occurred on the tests similar to training conditioning, push-up and sit-up. The smallest gain occurred on pull-up, arm-lift, and handgrip. The results showing strength gains from related conditioning activities are consistent with results in another demonstration of gains from a relatively short-term conditioning program (Wilmore, 1974).

b. There was little change in body weight, but both men and women decreased in percent body fat.

c. Although little average change occurred in the total sample on several tests, substantial changes occurred within the high- and low-scoring groups, frequently with decreases in the high scores and increases in the low ones, such as for fat body weight.

Conclusions

1. The STB provides a quick, safe, inexpensive method of measuring an applicant's strength and of monitoring the strength and body weight changes that result from physical conditioning programs.

2. Based on preliminary validation on a simulated cranking task, the STB is predictive of capability to perform muscularly demanding job tasks and thus should be evaluated further for occupational classification purposes.

3. Gains in strength and losses in fat body weight can be achieved in short-term conditioning programs, particularly by the persons most in need of the gain or loss.

4. The weight-to-height ratio as an assessment of overweight is of limited use and can even be misleading.

Recommendations

1. The STB should be administered, along with job task performance tests, to determine (a) the validity of the battery to predict a person's capability of performing muscularly demanding job tasks, and (b) Navy-wide percentages of men and women capable of performing job tasks, using base-rate data collected in the present analysis and standards of acceptable job performance.

2. The STB should be used to monitor strength and fat body weight changes that occur after recruit training as a consequence of school and job activities, especially handling heavy materials or equipment.

3. Instead of the weight-to-height ratio, skinfold or girth measurements should be used to assess overweight and to link body weight standards to capability of performing Navy job tasks.

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INTRODUCTION

Problem

Although many Navy tasks require substantial muscular capability, occupational strength and stamina standards for such tasks are not presently available. Without such standards and without methods of measuring the ability of men and women to perform to the standards, personnel may be assigned to billets in which they cannot fully perform all tasks or in which they could sustain injuries by attempting tasks beyond their strength. A particular problem for the Navy is that sea duty assignments may involve tasks that demand more strength than do the specific technical specialties to which personnel have been assigned.

In the past, many tests have been developed to predict the mental or technical capability of Navy men and women, but few tests have been developed to predict occupational strength capability. While strength factors have been identified, there has been little effort to demonstrate the relationship of specific strength measures to specific job tasks.

Background

Basic research has been conducted to measure general physical fitness and strength. For example, Fleishman (Fleishman, 1964; Fleishman, Kremer, & Shoup, 1961) identified nine basic elements of fitness and strength, including three primary strength factors: dynamic strength, static strength, and explosive strength. Dynamic strength involves movement or support of the weight of one's body, as exemplified in pull-ups and push-ups. Static strength involves the exertion of force against a heavy or immovable object, as in medicine-ball putting or in measuring handgrip strength with a dynamometer. Explosive strength involves a burst of effort to jump or project the body or some object as far as possible, as in the broad jump, the shuttle run, or the softball throw.

In a review of literature comparing the strength of men and women, Laubach (1976) concluded that, in static strength measures, women's average scores on upper torso and lower extremity measures were about 60 and 72 percent respectively of those for men. In dynamic strength measures, average women's scores were about 69 percent of those for men.

Although research on general fitness and strength has been conducted, few studies have demonstrated the relationship between basic strength measures and specific job tasks. Two examples of the kind of work needed include a project reported by Tenopyr (1977), who used the Fleishman tests to develop predictors for a telephone line installer job that required pole-climbing, ladder-positioning, and balancing abilities, and a study by Davis (1976), who used strength tests to predict performance of fire fighting tasks.

Purpose

The purpose of this project was to develop a strength test battery (STB) to predict how personnel will perform on Navy jobs that demand muscular strength. Specific objectives included:

1. Determine the time required to test body strength rapidly, safely, and efficiently for large numbers of personnel in the occupational selection and classification process.

2. Determine the amount of overlap in the distribution of men's and women's scores.

3. Determine the relationships between strength tests and anthropometric (body dimension) measures.

4. Conduct a preliminary evaluation of the battery's predictability, using a simulated job task criterion, a rapid cranking effort.

5. Determine test-retest reliability of the various STB parts.

6. Assess the STB's sensitivity in measuring physical changes that result from the recruit training conditioning program.

7. Identify uses of a muscular strength data base for men and women entering the Navy.

METHOD

Test Selection Considerations

Fourteen tests--eight strength tests and six anthropometric tests--were selected for the STB based on the following criteria:

1. The tests should primarily measure upper torso capability, because (a) most Navy jobs appear to emphasize musculoskeletal demands in that area, and (b) limiting exertion to this area minimizes cardiac or hernia injuries to applicants.

2. Testing time and space requirements should be minimal, so that recruiting stations or recruit training centers can process applicants efficiently.

3. The instruments and procedures used should not require special training.

The selection of five strength tests was influenced by their high positive or negative loadings on Fleishman's (1964) dynamic and static strength factors. Two of these tests loaded highest on the static strength factor--handgrip (.72) and arm-pull (.71), and three loaded highest on the dynamic strength factor--pull-up (.81), push-up (.74), and bent-arm hang (.73). Body weight loaded -.43 on the dynamic strength factor and .70 on the static strength factor.

Strength Tests

The eight strength tests measure three types of strength--static (3), dynamic (4), and power (1). The three static strength tests were handgrip, arm-pull, and arm-lift, which were measured by dynamometers (see Figures 1 through 3). The four dynamic strength tests were sit-up, push-up, pull-up, and bent-arm hang. The power test measured upper torso power using a hand-cranked ergometer to simulate job tasks that involve a turning or pumping activity (of a wheel, lever, or handle) at maximum effort for brief periods (see Figure 4). Instruments and procedures used for the tests are described in the appendix.

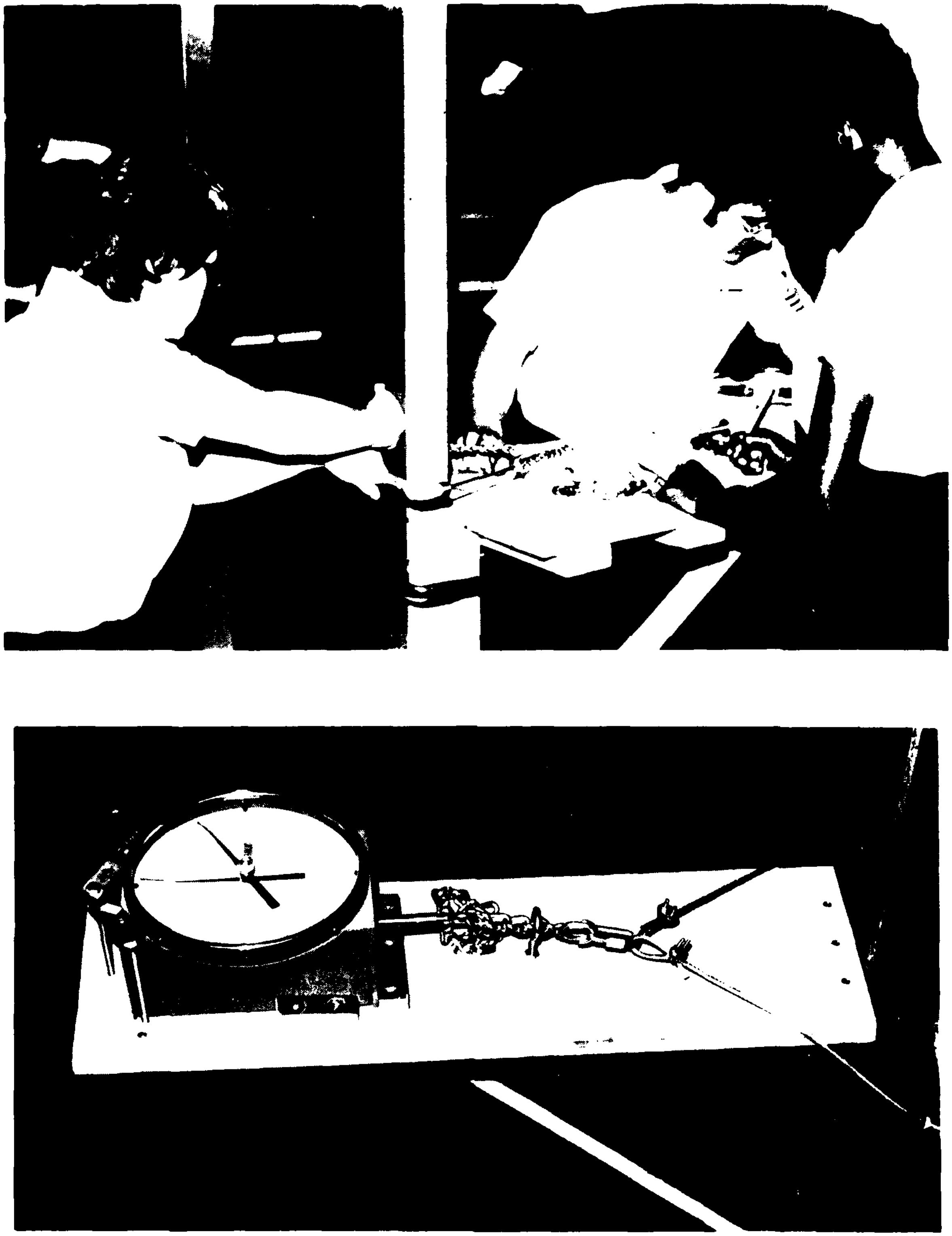

Figure 1. Arm-pull dynamometer.

Figure 2. Handgrip dynamometer.

Figure 3. Arm-lift dynamometer.

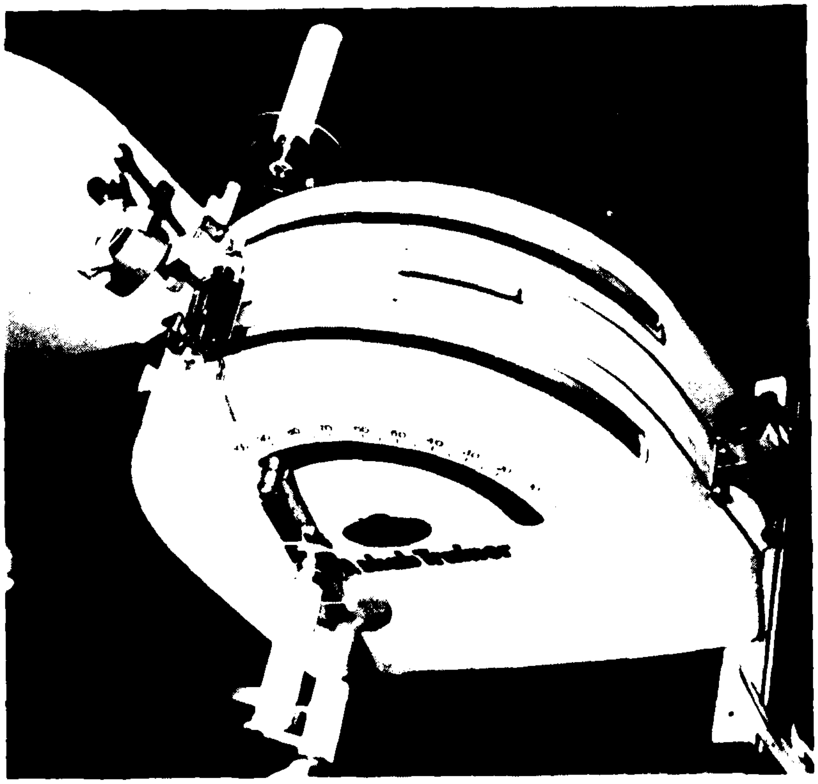

Figure 4. Ergometer.

Anthropometric Tests

The battery's six anthropometric tests included routine measurement of height and weight (hereafter referred to as total body weight--TBW) and skinfold measures obtained at four body sites--triceps, subscapula, abdomen, and thigh. (Skinfold measurements provide a quick, convenient assessment of subcutaneous fat, from which separate components of lean body weight (LBW) and fat body weight (FBW) can be estimated.) The skinfold measures were obtained by using the Harpenden skinfold caliper (Quinton Company Number 3496).

Derived Body Weight Measures

In addition to the 14 tests in the STB, anthropometric measures were derived by calculating LBW, FBW, and three alternative measures of relative body weight: weight devided by height (WT/HT), FBW divided by LBW (F/LBW), and percent body fat (PCFAT)--FBW divided by TBW multiplied by 100. The skinfold measurement from the abdominal site was used to estimate men's PCFAT: and the skinfold measurements from the triceps, subscapular, and thigh sites, women's PCFAT. The estimation procedures of Wilmore and Behnke (1969, 1970) were used for calculation because their subjects--healthy, normal, college-aged persons--were similar to Navy recruits.

Sample

The STB was administered to recruits at the Recruit Training Center (RTC), Orlando, Florida, the only RTC that trains women recruits. The tests were administered in 1978 at the beginning and the end of the 7-week recruit training program. The pretest sample included 350 men and 269 women; and the posttest sample, 493 men and 243 women. Recruits are organized into companies of 60 to 80 members for the 7-week training. However, because of attrition and setbacks, about 25 percent of a company's members usually do not finish training in the same company as the one in which they were initially assigned. To obtain data for a longitudinal analysis (i.e., to compare the pretest and posttest scores for the same recruits), the same companies tested at the beginning of recruit training were retested at the end of training. Because of the attrition and setbacks, only about 75 percent of the data were usable for the longitudinal sample.

The STB was administered in the RTC gym--the pretest on Training "Work-Day" 1-1 (in early spring, early morning, when the gym was relatively cool) and the posttest on Training Workday 7-2 (in late spring, midafternoon, when the temperature was 85° Fahrenheit inside the gym and 94° Fahrenheit outside). Those were the only times the recruits, who were on a very tight training schedule, could be scheduled for the tests. Whether the time of day or temperature differences influenced the results is problematical.

Analyses

The pretest sample was used to develop base-rate data for the total population entering the Navy, regardless of subsequent attrition in training. Means, standard deviations, and intercorrelations were calculated. To compare the differences between men's and women's scores, two indices were calculated: the women's mean divided by the men's mean times 100 percent, and the Tilton (1937) percentage overlap.

To track gains or losses that occurred during training, the only data used for the longitudinal sample were for those recruits with both pretest and posttest scores (as noted previously, about 75% of the pretest sample). The relative size of the changes was calculated by

$$\frac{\bar{X}_{Post} - \bar{X}_{Pre}}{\bar{X}_{Pre}} \times 100\%$$

and evaluated with the two-tailed t-test for correlated means (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975, page 270).

Subgroups

To determine whether the training program had different effects on high and low scorers, three subgroups of the longitudinal sample were formed based on scores obtained on the three static strength tests: the top quarter, the bottom quarter, and the middle half. To avoid regression effects (Thorndike, 1942), subgroups were formed on one score and analyzed on others. The subgroups were formed from the Trial 1 score for arm-lift and from the Trial 1 average right-and left-hand score for arm-pull and handgrip. A separate sort was performed on each of the measures. Thus, a recruit with a score in the top quarter for handgrip might not, for example, be in the top quarter for arm-pull or arm-lift. The data used for analyses were the average of Trials 2 and 3.

A different design was employed for evaluating changes in high and low body weight scores, because multiple trial data, such as the dynamometer measurements for static strength, were not available. The pretest 20th and 80th percentile scores were calculated (again, separately for each measure) and used as upper and lower base, or criterion-referenced, scores. Thus, separate subgroups were not formed. The base score was applied to the posttest data to determine the percentages of the total group falling above and below the base score.

Evaluating Test Reliability

Reliability of the three static strength measures was determined by correlating the scores for Trials 2 and 3. Reliability of the four skinfold measures was determined by correlating the posttest and retest (24 hours later) scores of a subsample.

RESULTS

Test Administration Time and Efficiency

Table 1,[1] which provides the average test administration times (based on subsamples of 46 men and 61 women), indicates that both men and women required about 12 minutes (including the job task simulation). No single test monopolized a large part of that time. The longest test time for men was 1.8 minutes on arm-pull; and the longest time for women, 2.2 minutes--for both arm-pull and skinfold measurements.

The tests were administered safely and quickly by persons who required no specialized training. There was no incident of injury or illness associated with test administration. The staff administering the STB, who had no special background in this kind of

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[1]Because of the large number of tables and figures in this section relative to the amount of text, they are placed at the end of the section, commencing on page 11.

testing, were members of the Navy Occupational Development Analysis Center (NODAC), assisted by RTC instructors on the physical conditioning staff.

Overlap in Distributions of Men's and Women's Average Scores

Table 2 presents the pretest means and standard deviations for the three kinds of strength tests, as well as for the two indices that compare the men's and women's averages. Men's and women's averages were closest on a mid-torso dynamic strength test--the sit-up, where the means for women was 76 percent of that for men. The greatest differences were on the upper torso dynamic strength tests--push-up, pull-up, and bent-arm hang, where the means for women were 10, 5 and 23 respectively of that for men. The comparisons on the upper torso static strength tests--handgrip, arm-pull, and arm-lift--appear to be consistent with the conclusions of the Lauback (1976) review cited earlier: Women's means were generally 60 percent of men's means. The Tilton (1937) index of overlap, however, indicates that very few of the women's static strength scores are similar to those for men; that is, only 12 or 13 percent of the score distributions overlap.

The means for the anthropometric measures included in Table 2 confirm the normal tendency for women to have more body fat than men. Women had higher averages on three of the four skinfold measures, as well as on FBW, F/LBW, and PCFAT. For example, on PCFAT, the women's average was about 25 percent; and the men's, about 14 percent.

Correlations Between Strength Tests and Anthropometric Measures

For both women's and men's body weight measures, there were generally significant negative correlations with the upper torso dynamic strength tests and significantly positive correlations with the static strength and power tests (see Tables 3 and 4). For example, as shown in Table 4, women's TBW correlates negatively with push-up (-.20), pull-up (-.15), and bent-arm hang (-.23); but positively with handgrip (.25), arm-pull (.36), arm-lift (.35), and ergometer (.34). Women's PCFAT correlates negatively with push-up (-.24), pull-up (-.24), and bent-arm hang (-.27); but positively with arm-pull .14, and ergometer .20. (The correlations with handgrip (-.04) and arm-lift (.06) are not statistically significant.) Table 3 shows that the correlations for men in these groups of measures reflect similar results; however, the correlation coefficients for men are usually larger than for women.

Predictability of the Simulated Job Task Criterion

Several of the strength and anthropomorphic measures were found to be predictive of a simulated job task criterion--a rapid cranking effort measured with an ergometer (see ergometer column in Tables 3 and 4). For men, the best predictor was LBW (.45), and for women, ARMPL (.36). Generally, the body weight and static strength measures were better predictors than were the dynamic strength ones.

Test Reliability

For calculation of Pearson correlations as an estimate of reliability, multiple trials or retest data were available only for the static strength and skinfold tests (see Table 5). These measures, using the dynamometers and the skinfold caliper, were found to be quite stable, with reliabilities mostly in the .90s.

The reliabilities reported by Fleishman (1964) for static and dynamic strength tests were as follows: handgrip, .91; arm-lift, .83; sit-up, .72; push-up, .88; pull-up, .93; and bent-arm hang, .77. Because the testing procedures in the present study were similar to Fleishman's,[2] it was assumed that the Fleishman reliabilities would be reasonably representative, with the static strength measures more stable than the dynamic ones.

Physical Changes During Recruit Training

Strength Measures

From pretest to posttest in the longitudinal sample, the largest relative gains in strength occurred on push-up (205 percent) and sit-up (23 percent) for women, and on push-up (36 percent) and ergometer (17 percent) for men (see Figure 5).[3] The smallest gains, or some loss, occurred on pull-up, arm-lift, and handgrip.

Although the women's relative gains on push-up and sit-up were greater than the men's, the men's absolute gains were similar or greater (see Table 6). The average increase on push-up was 6.6 for men and 3.9 for women; on sit-up, averages were 2.4 and 2.9 respectively.

Anthropometric Measures

For both women and men, there was little change in TBW during recruit training. Women gained a pound and men lost about a pound (see Figure 6 and Table 6). The women's gain appears to be from a gain of 1.2 pounds LBW and a loss of .2 pound FBW, resulting in a decrease in PCFAT of .3 percent. Men's PCFAT decreased 1.3 percent, a relative decrease of 9 percent.

High and Low Scores

For several tests, little average change occurred in the total longitudinal sample; however, substantial changes did occur within high and low scoring groups. For example, although women's handgrip scores increased only a relative 1 percent (see Figure 5), the group in the bottom quarter of the pretest group increased their scores a relative 17 percent; and the group in the top quarter, decreased theirs 9 percent (see Figure 7). Generally, if decreases occurred in the top scoring group, and increases or little change occurred in the bottom scoring group, the results were also reflected in the shrinkage of the variance (the average of the squared deviations from the mean). For example, men's and women's variances shrank a relative 17 and 22 percent on handgrip, and 48 and 51 percent on arm-lift (see Table 6).

Similar results occurred on some of the body weight measures. Relative changes in TBW were down less than 1 percent for men and up less than 1 percent for women, but the

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[2]There were two deviations from Fleishman's (1964) testing procedures: (1) On static strength tests, the average of Trials 2 and 3 were used instead of the best score from Trials 1-3; and (2) the bent-arm hang was initiated with the examinees' eyes level with the bar instead of with a pull-up from below the bar.

[3]The results showing strength gains from related conditioning activities are consistent with results in another demonstration of gains from a relatively short-term conditioning program (Wilmore, 1974)

variances shrank 34 and 8 percent respectively on TBW, and 51 and 21 percent on FBW (see Table 6 and Figure 6).

The changes in percentages of the groups above and below selected base scores (set on the 20th and 80th percentiles of the pretest data) are displayed in Figures 8 and 9. For example, 20 percent of the men started recruit training with 30 pounds or more of FBW, but only 9 percent still had that much on completion of training. Also, the 20 percent with the least FBW--14 pounds or less--decreased to 17 percent. Likewise, the percentages of women with FBW of 38 or more pounds and of 26 or less pounds both decreased from 20 to 15 percent.

Table 1

Average Test Administration Time

Test	Minutes: Men (N = 46)	Minutes: Women (N = 61)
Sit-Up	0.8	0.9
Push-Up	1.0	0.8
Pull-Up	0.9	0.8
Bent-Arm Hang	1.0	0.8
Dynamic Strength Total	3.7	3.3
Handgrip	1.4	1.6
Arm-Pull	1.8	2.2
Arm-Lift	0.9	0.6
Static Strength Total	4.1	4.4
Ergometer	1.4	1.6
Power Total	1.4	1.6
Height and Weight	0.8	0.8
Skinfold Sites (4)	1.5	2.2
Anthropometric Total	2.3	3.0
Total	11.5	12.3

Table 2

STB Pretest Scores
For Men (N = 350) and Women (N = 269) Recruits

Test or Derived Measure	Abbrev.	Sex	Mean	SD	$\frac{W}{M} \times 100$	Percentage Overlap[a]
			Strength Measures			
Dynamic Strength						
Sit-Up (number)	SITUP	M W	17.96 13.61	3.29 3.01	76	49
Push-Up (number)	PSHUP	M W	18.74 1.91	8.10 3.24	10	14
Pull-Up (number)	PULUP	M W	5.93 0.30	3.63 0.84	5	20
Bent-Arm Hang (seconds)	BNTHG	M W	33.27 7.76	14.44 6.38	23	22
Static Strength						
Handgrip (kilograms)	HGRIP	M W	45.88 28.20	7.78 6.04	61	12
Arm-Pull (pounds)	ARMPL	M W	147.53 79.35	26.07 17.55	54	12
Arm-Lift (pounds)	ARMLF	M W	104.75 60.93	17.45 11.44	58	13
Power						
Ergometer (revolutions)	ERGOM	M W	58.38 34.97	9.42 8.49	60	19
			Anthropometric Measures			
Skinfold Measurements						
Tricep	SKTRI	M W	9.30 15.36	4.05 5.12	165	51
Subscapular	SKSCA	M W	10.41 11.02	3.98 3.10	106	93
Abdomen	SKABD	M W	15.72 15.25	7.99 5.23	97	72
Thigh	SKTHI	M W	11.49 20.93	4.62 10.52	182	53
Height (inches)	HT	M W	68.79 64.41	2.72 2.55	94	41
Body Weight						
Total Body Weight (pounds)	TBW	M W	157.83 128.01	26.00 14.41	81	46
Lean Body Weight[b]	LBW	M W	134.97 96.23	17.08 8.90	71	14
Fat Body Weight	FBW	M W	22.82 31.78	10.83 6.32	139	60
Fat-to-Lean Body Weight	F/LBW	M W	0.17 0.33	0.06 0.05	194	14
Percent Body Fat	PCFAT	M W	13.90 24.62	4.59 2.63	177	14
Weight-to-Height	WT/HT	M W	2.29 1.99	0.34 0.19	87	57
Age		M W	19.94 21.00	2.43 2.78	105	84

[a]Based on Tilton's (1937) measurement of overlapping.

[b]LBW estimated by Wilmore and Behnke's Equation 5, Table III (1969, 1970).

Table 3

STB Pretest Means, Standard Deviations, and Intercorrelations for Men (N = 269)

Test or Derived Measure	1	2 HT	3 TBW	4 SKTRI	5 SKSCA	6 SKABD	7 SKTHI	8 LBW	9 FBW	10 F/LBW	11 PCFAT	12 WT/HT	13 SITUP	14 PSHUP	15 PULUP	16 BNTHG	17 HGRIP	18 ARMPL	19 ARMLF	20 ERGOM
1. Age		.01	.12	.15	.27	.11	.15	.11	.13	.12	.13	.13	-.08	-.05	-.10	-.08	.10	-.04	.02	.05
2. Height (HT)			.46	.06	.06	.09	.03	.52	.28	.16	.17	.24	-.08	-.31	-.34	-.24	.25	.19	.22	.22
3. Total Body Weight (TBW)				.58	.70	.66	.53	.96	.89	.74	.74	.97	-.01	-.33	-.55	-.45	.34	.33	.38	.43
4. Skinfold--Tricep (SKTRI)					.64	.64	.71	.46	.67	.66	.66	.62	-.09	-.26	-.52	-.37	.05	-.03	.09	.13
5. Skinfold--Subscapular (SKSCA)						.65	.56	.60	.74	.69	.68	.75	-.08	-.29	-.51	-.43	.08	.06	.14	.18
6. Skinfold--Abdomen (SKABD)							.60	.42	.93	.99	.98	.70	-.06	-.30	-.51	-.41	.10	.15	.16	.17
7. Skinfold--Thigh (SKTHI)								.42	.62	.62	.63	.58	-.11	-.25	-.50	-.37	-.02	.00	.04	.12
8. Lean Body Weight (LBW)									.73	.52	.53	.91	.01	-.29	-.47	-.39	.37	.34	.40	.45
9. Fat Body Weight (FBW)										.96	.96	.90	-.05	-.35	-.58	-.47	.22	.25	.29	.31
10. Fat-to-Lean Body Weight (F/LBW)											.99	.77	-.05	-.33	-.55	-.44	.15	.19	.22	.22
11. Percent Body Fat (PCFAT)												.77	-.05	-.33	-.56	-.44	.15	.19	.22	.23
12. Weight-to-Height (WT/HT)													.01	-.28	-.51	-.43	.30	.31	.36	.40
13. Sit-Up (SITUP)														.30	.19	.18	.06	.27	.23	.20
14. Push-Up (PSHUP)															.54	.41	.06	.08	.13	.10
15. Pull-Up (PULUP)																.61	.06	.09	.03	.03
16. Bent-Arm Hang (BNTHG)																	.12	.07	.09	.03
17. Handgrip (HGRIP)																		.47	.50	.23
18. Arm-Pull (ARMPL)																			.49	.30
19. Arm-Lift (ARMLF)																				.35
20. Ergometer (ERGOM)																				
Mean	20.39	68.79	157.83	9.30	10.41	15.72	11.49	134.97	22.82	.17	13.90	2.29	17.96	18.74	5.93	33.27	45.88	147.53	104.75	58.38
Standard Deviation	2.51	2.72	26.00	4.05	3.98	7.99	4.62	17.08	10.83	.06	4.59	.34	3.29	8.10	3.63	14.44	7.78	26.07	17.45	9.42

Note. Correlation values of .09-.12 are significant at the .05 level; those of .13-.15, at the .01 level; and those of .16+, at the .001 level.

Table 4

STB Pretest Means, Standard Deviations, and Intercorrelations for Women (N = 269)

Test or Derived Measure	1	HT 2	TBW 3	SKTRI 4	SKSCA 5	SKABD 6	SKTHI 7	LBW 8	FBW 9	F/LBW 10	PCFAT 11	WT/HT 12	SITUP 13	PSHUP 14	PULUP 15	BNTHG 16	HGRIP 17	ARMPL 18	ARMLF 19	ERGOM 20
1. Age		-.05	-.04	-.04	-.08	-.05	-.02	-.03	-.05	-.07	-.07	-.03	.01	-.04	.07	.04	.05	.00	-.03	.04
2. Height (HT)			.59	.02	.03	.01	-.02	.64	.43	.19	.20	.28	-.04	-.30	-.08	-.15	.22	.21	.24	.13
3. Total Body Weight (TBW)				.44	.40	.26	.23	.96	.92	.68	.69	.94	.11	-.20	-.15	-.23	.25	.36	.35	.34
4. Skinfold-- Tricep (SKTRI)					.37	.52	.67	.22	.70	.85	.85	.52	-.02	-.21	-.27	-.25	-.16	.02	.06	.12
5. Skinfold-- Subscapular (SKSCA)						.43	.16	.25	.57	.65	.65	.47	-.06	-.15	-.13	-.22	.02	.03	.03	.06
6. Skinfold-- Abdomen (SKABD)							.38	.12	.44	.55	.54	.31	-.02	-.21	-.20	-.14	-.11	.06	-.12	.11
7. Skinfold-- Thigh (SKTHI)								.00	.51	.72	.72	.28	.04	-.12	-.10	-.08	-.18	.03	-.14	.11
8. Lean Body Weight (LBW)									.79	.46	.47	.87	.13	-.15	-.10	-.18	.32	.38	.41	.33
9. Fat Body Weight (FBW)										.91	.91	.92	.08	-.23	-.20	-.27	.12	.28	.22	.30
10. Fat-to-Lean Body Weight (F/LBW)											.99	.74	.03	-.24	-.23	-.26	-.04	.14	.05	.20
11. Percent Body Fat (PCFAT)												.74	.03	-.24	-.24	-.27	-.04	.14	.06	.20
12. Weight-to-Weight (WT/HT)													.15	-.11	-.15	-.21	.20	.33	.31	.34
13. Sit-Up (SITUP)														.23	.15	.30	.20	.22	.22	.28
14. Push-Up (PSHUP)															.49	.59	.22	.11	.29	.17
15. Pull-Up (PULUP)																.48	.23	.08	.19	.12
16. Bent-Arm Hang (BNTHG)																	.25	.24	.43	.20
17. Handgrip (HGRIP)																		.33	.43	.36
18. Arm-Pull (ARMPL)																				.22
19. Arm-Lift (ARMLF)																				
20. Ergometer (ERGOM)																				
Mean	21.45	64.41	128.00	15.36	11.02	15.25	20.93	96.23	31.78	.33	24.62	1.99	13.61	1.92	.30	7.76	28.20	79.35	60.93	34.97
Standard Deviation	2.77	2.55	14.41	5.12	3.10	5.23	10.52	8.90	6.32	.05	2.63	.19	3.01	3.24	.84	6.38	6.04	17.55	11.44	8.49

Note. Correlation values of .10-.13 are significant at the .05 level; those of .14-.17, at the .01 level; and those of .18+, at the .001 level.

Table 5

Test Reliability

Test	Men r	Women r
Static Strength[a]		
Handgrip	.93	.94
Arm-Pull	.94	.93
Arm-Lift	.89	.90
Skinfold Sites[b]		
Triceps	.92	.90
Subscapular	.92	.95
Abdominal	.94	.75
Thigh	.97	.82

[a]Pretest Trials 2 and 3 scores (N = 350 men and 269 women).
[b]Posttest and retest (24 hours later) scores (N = 36 men and 35 women).

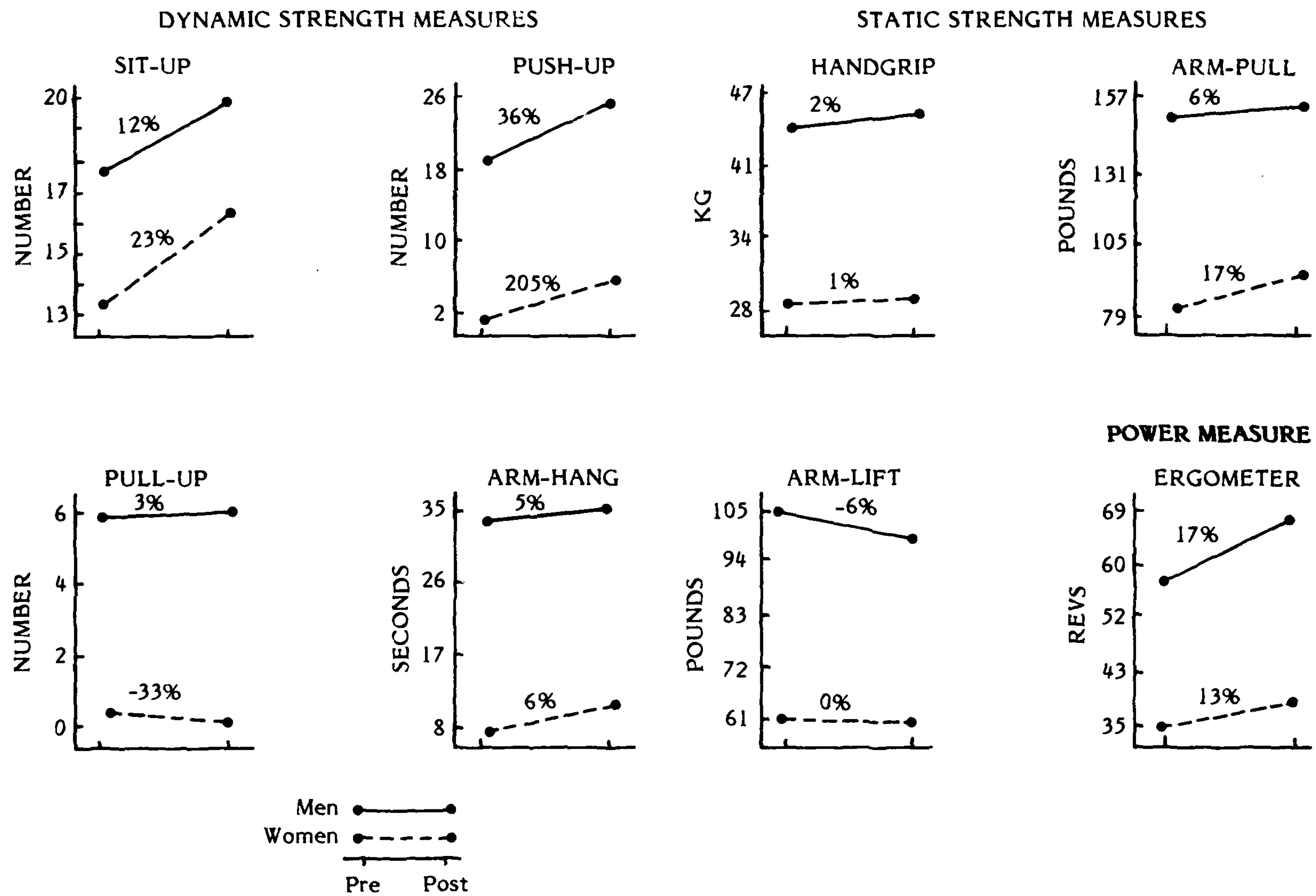

Figure 5. Relative changes in average strength scores from pretest to posttest.

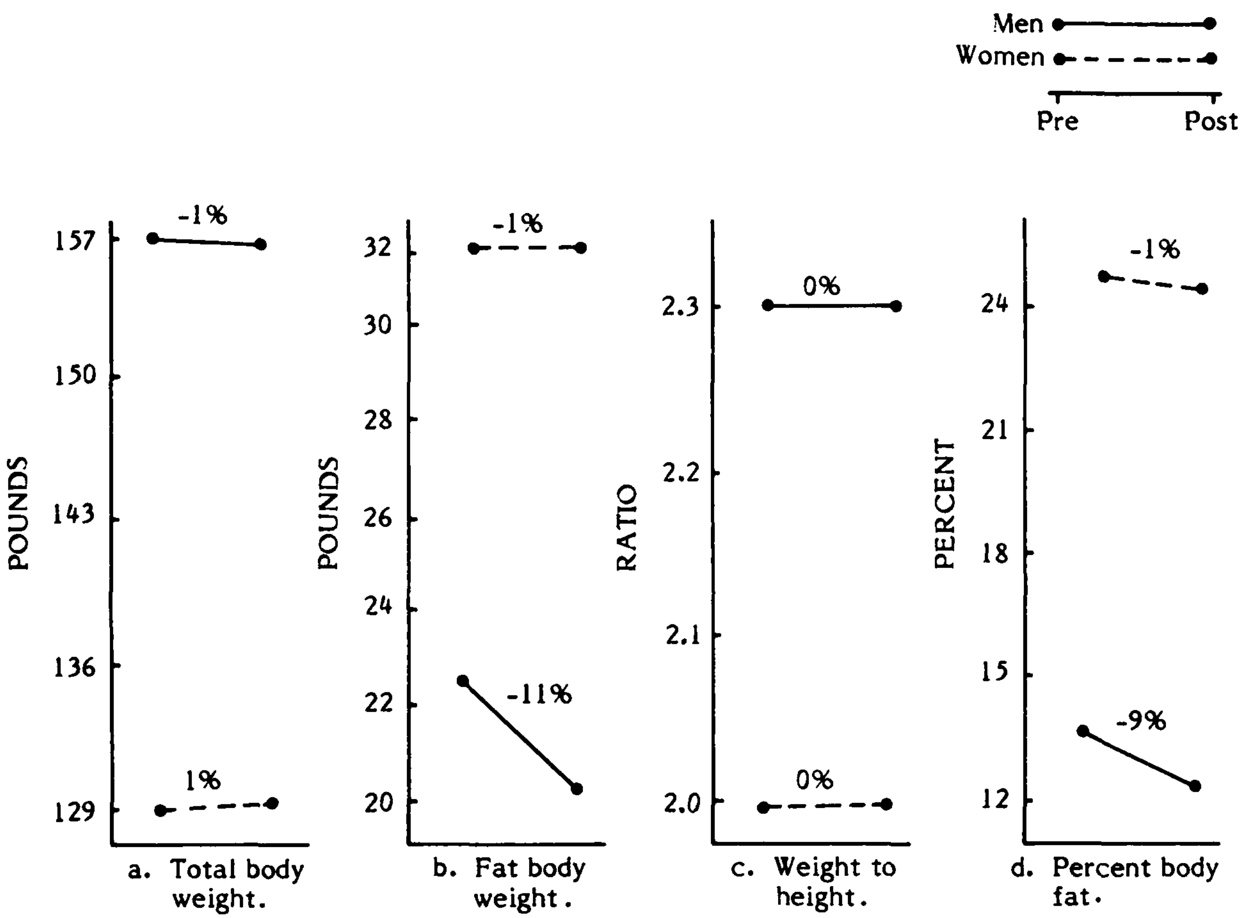

Figure 6. Relative changes in average body weight scores from pretest to posttest.

Table 6

Strength and Weight Changes From Pretest to Posttest

		Men			Women		
Measure	Test	Mean	T Value	Variance and % Change	Mean	T Value	Variance and % Change
Strength							
SITUP	Pre	18.2		10.62	13.9		7.61
	Post	20.6		10.60	16.9		10.69
	Diff	2.4***	12.55	-0%	2.9***	14.03	40%
PSHUP	Pre	19.2		60.00	2.2		10.99
	Post	25.8		69.14	6.1		37.30
	Diff	6.6***	17.14	15%	3.9	13.10	239%
PULUP	Pre	6.2		12.26	0.3		0.79
	Post	6.4		11.04	0.2		0.90
	Diff	0.2	1.32	-10%	-0.1	-2.18	14%
BNTHG	Pre	35.0		189.34	8.1		40.37
	Post	34.8		162.34	8.2		36.35
	Diff	-0.2	-0.38	-14%	0.1	0.24	-10%
HGRIP	Pre	46.0		61.75	28.5		37.25
	Post	46.1		51.31	28.5		28.89
	Diff	0.1	0.30	-17%	0.1	0.18	-22%
ARMPL	Pre	148.7		719.15	80.2		285.17
	Post	156.5		570.06	92.5		316.98
	Diff	7.8***	6.16	-21%	12.3***	10.90	11%
ARMLF	Pre	106.0		327.28	61.7		141.97
	Post	99.6		169.78	61.5		69.21
	Diff	-6.4***	-6.71	-48%	-0.2	-0.28	-51%
ERGOM	Pre	58.4		84.47	35.6		65.37
	Post	69.3		77.49	41.0		64.45
	Diff	10.9***	19.77	-8%	5.4***	10.23	-1%
Body Weight							
TBW	Pre	157.1		617.87	128.5		201.84
	Post	156.2		406.34	129.6		184.72
	Diff	-0.9*	-1.99	-34%	1.0**	3.11	-8%
LBW	Pre	134.4		265.53	96.4		77.07
	Post	136.0		206.53	97.6		75.17
	Diff	1.6***	4.56	-22%	1.2***	5.45	-2%
FBW	Pre	22.6		111.24	32.1		39.35
	Post	20.2		54.80	32.0		31.06
	Diff	-2.5***	-7.47	-51%	-0.2	-0.72	-21%
PCFAT	Pre	13.9		20.61	24.8		6.83
	Post	12.6		10.53	24.5		4.63
	Diff	-1.3***	-7.47	-49%	-0.3*	-1.93	-32%
WT/HT	Pre	2.3		0.11	2.0		0.03
	Post	2.3		0.07	2.0		0.03
	Diff	0.0	-1.32	-36%	0.0	5.60	0%

Note. N = 266 men, 195 women. The cases used were only those for which both pretest and posttest scores were available. The difference (Diff) is posttest minus pretest, so that a positive difference indicates a gain. Differences were calculated and then rounded.

*$p < .05$.
**$p < .01$.
***$p < .001$.

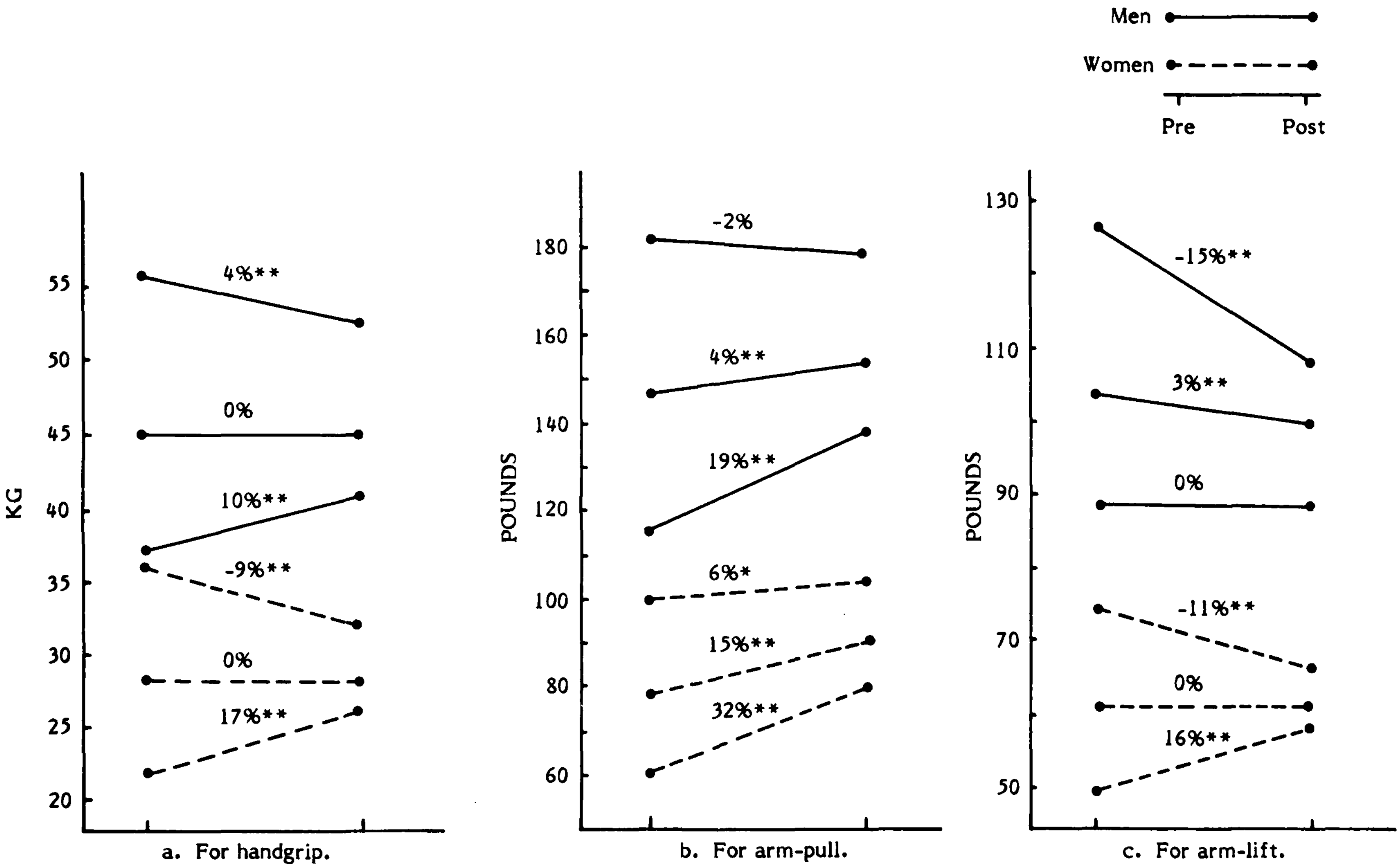

Figure 7. Relative changes in average static strength scores by high, middle, and low scoring groups of men (N = 266) and women (N = 195).

*p <.01.
**p <.001.

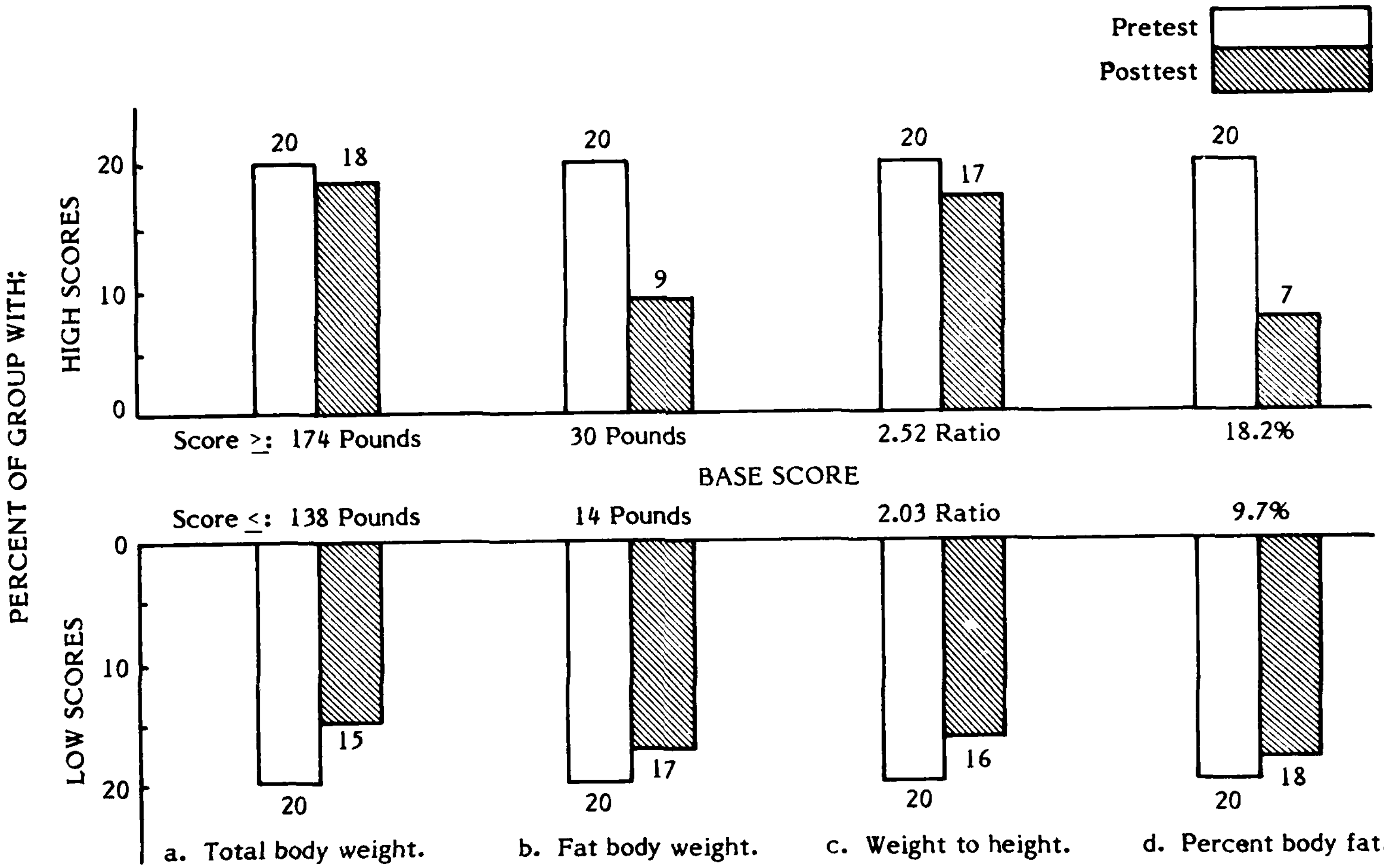

Figure 8. Changes in size of men's groups with high and low body weight scores.

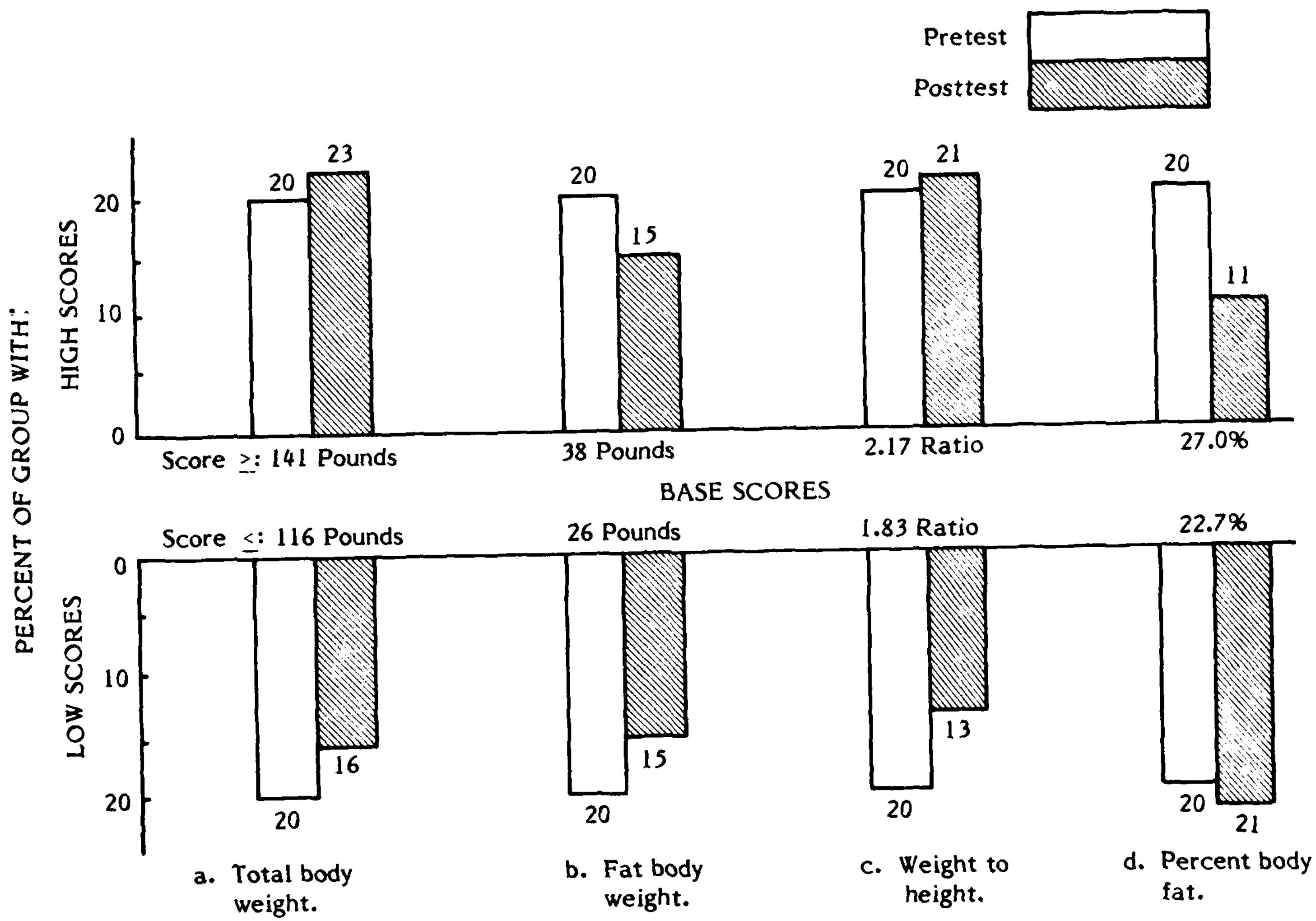

Figure 9. Changes in size of women's groups with high and low body weight scores.

DISCUSSION

Usefulness of the Data Base

In the context of developing an STB for occupational classification, the present test results provide useful data bases that represent the entire population of men and women entering the Navy. In other phases of this project, muscularly demanding job tasks (in specific ratings or for general shipboard duties) will be identified and documented. Tests of these tasks will be designed and administered, along with the STB.

The groups to whom these tests will be administered will be relatively small and probably will not be representative of Navy-wide populations. However, management will have available STB base-rate data, such as the present results from a recruit entry population, for assessing the Navy-wide impact of classification standards that may be under consideration.

Gains and Losses from Physical Conditioning Activities

The differences between the STB pretest and posttest scores indicated that the largest gains occurred on push-up and sit-up; and the smallest, on pull-up, arm-lift, and handgrip. These changes were expected, because the body efforts applied on some of the STB measures, those on which the largest gains occurred, were similar to the efforts in the recruit physical conditioning program. (Recruit training activities include sit-up, push-up, flutter kick, body builder, jumping jack, swimming to stay afloat, and running.) The STB results indicate that these short-term conditioning activities can bring about measurable strength and body weight changes. It may be noted that there was no activity in the recruit program that exercised the biceps (e.g., by pull-up or weight-lifting).

Between the recruits' substantial gains on push-up and small gains or losses on pull-up and arm-lift were the moderate gains on arm-pull and ergometer. Considering the type of effort applied on these two tests, a concurrent "push-pull" action, the moderate gains may also reflect the partial conditioning from the activities in the present recruit program--conditioning for the "push" side but not for the "pull" side.

The STB results are consistent with another demonstration of strength gains from a short-term conditioning program for college-aged men and women. Wilmore (1974) reported substantial gains in upper torso strength after a 10-week (two 45-minute periods per week) weight training program. Increases for men and women on the curl were 19 and 11 percent, respectively; and on the bench press, 17 and 29 percent. Wilmore also reported substantial reduction in FBW but negligible increase in muscle mass (thus, no "masculinizing" effect for women).

If, in another phase of this project, weight-lifting is found to be a frequent or important requirement in Navy jobs, management might consider it appropriate to increase emphasis on this kind of activity in conditioning programs. The effect of new conditioning activities and the amount of improvement from them could be monitored with the arm-lift test. Furthermore, because little is known about the amount of strength that may be gained from handling of heavy materials on the job, the STB could be administered to evaluate on-the-job conditioning effects.

Special Interest in High and Low Scores

The analyses of differential changes in high and low groups and of the shrinkage in variance underscore the battery's usefulness to monitor subgroups in which there is special interest. For example, if a minimum specified lifting capability (as measured on arm-lift) is a major concern for some jobs, personnel who begin a conditioning program scoring below the specified minimum could be monitored separately. Their gain (or loss) might be in the opposite direction from their total group's average score. For other requirements, such as percent body fat (PCFAT), a maximum score may be of concern. In that case, persons scoring above some specified maximum could be similarly monitored.

Generally, the results of the analyses suggest that the present conditioning program has desirable effects on some subgroups, even on some activities for which the average scores of the total group reflect little change. On PCFAT, for example, the program appears to slim down the fattest recruits and fatten the underweight one. On the other hand, when strength test losses occur for the high scoring groups, the results suggest that the program is not adquately maintaining the fitness of persons who enter in top condition.

Utility of the STB as a Classification Test

Pending validation studies of the STB with a variety of job task criteria, the results of the present analyses indicate that the STB displays characteristics that would make it suitable for personnel classification for Navy jobs:

1. For the simulated job task criterion, several tests were predictive of the ergometer performance, with validities in the .30s and .40s (see ergometer columns of Tables 3 and 4). Combining a few of the tests as a composite predictor would probably boost the validity into the .50s.

2. The tests were administered safely and quickly by persons who required no specialized training. There was no incident of injury or illness associated with the test administration.

3. The overall testing time required for each person, about 12 minutes, included the simulated criterion. For classification purposes at an Armed Forces Examining and Entrance Station (AFEES), administration of only the three static strength measures (in less than 5 minutes--see Table 1) would probably be sufficient.

Assessment of Body Weight

Present Navy standards of allowable body weight for enlistment and reenlistment are specified in terms of a maximum and minimum weight for a given height; that is, a weight-to-height ratio (WT/HT). This method is not very useful for assessing overweightness or fatness. It can even result in classifying persons who are most fit--top athletes--as overweight (Wilmore, 1975). The separate components of LBW and FBW cannot be estimated from the WT/HT ratio.

Some of the results of an effective physical conditioning program, decrease in FBW and increase in LBW, produce little change in TBW. This was essentially the result in the present case (see Table 5, although the decrease in women's FBW was not statistically significant). Furthermore, the WT/HT measure is not nearly so sensitive as the PCFAT measure for monitoring changes in overweight persons. For example, only slight changes occurred in the proportions of recruits with WT/HT ratios above the high base score (see Figure 8)--a decrease from 20 to 17 percent of the men and an increase from 20 to 21 percent of the women. By comparison, proportions above the high PCFAT base scores dropped substantially, from 20 to 7 percent of the men and from 20 to 11 percent of the women.

It is important to consider the type of person most capable of performing muscularly demanding job tasks. For the various measures of body weight, the intercorrelations in Table 3 indicate positive relationship for ergometer and arm-lift with TBW, WT/HT, and PCFAT. The correlations of these three body weight measures are as follows:

1. Men--Ergometer, .43, .40, and .23; arm-lift, .38, .36, and .22.
2. Women--Ergometer, .34, .34, and .20, and arm-lift, .35, .31, and .06.

Thus, not only the heavier but also the fatter persons appear to be more capable of cranking or lifting heavy loads. Although the relationship of fatness to general health is also an important issue, moderate obesity does not appear to be a medical problem for some body conditions (e.g., for respiratory dysfunction) (Wolfe, Hodgson, Barlett, Nicholas, & Buskirk, 1976).

CONCLUSIONS

1. The STB provides a quick, safe, inexpensive method of measuring an applicant's strength and of monitoring strength and body weight changes resulting from physical conditioning activities.

2. Based on a preliminary validation on a simulated cranking task, the STB is predictive of capability to perform muscularly demanding job tasks and thus should be evaluated further for occupational classification purposes.

3. Gains in strength and losses in FBW can be achieved in short-term conditioning programs, particularly by the persons most in need of the gain or loss.

4. The WT/HT ratio as an assessment of overweight is of limited use and can even be misleading.

RECOMMENDATIONS

1. The STB should be administered, along with job task performance tests, to determine (a) the validity of the STB to predict a person's capability of performing muscularly demanding job tasks, and (b) Navy-wide percentages of men and women capable of performing job tasks, using base-rate data collected in the present analysis and standards of acceptable job performance.

2. The STB should be used to monitor strength and fat body weight changes that occur after recruit training as a consequence of school and job activities, especially handling heavy materials or equipment.

3. Skinfold or girth measures, instead of the WT/HT ratio, should be used to assess overweight and to link body weight standards to capability of performing Navy job tasks.

REFERENCES

Davis, P. O. Relationships between simulated fire fighting tasks and physical performance measures (Doctoral dissertation from University of Maryland). Ann Arbor, MI: University Microfilms International, 1976.

Fleishman, E. A. The structure and measurement of physical fitness. Englewood Cliffs, NJ: Prentice-Hall, 1964.

Fleishman, E. A., Dremer, E. J., & Shoup, G. W. The dimensions of physical fitness--A factor analysis of strength tests (Yale University Tech. Rep. 2). Office of Naval Research, August 1961.

Laubach, L. L. Muscular strength of women and men: A comparative study (AMRL-TR-75-32). Wright-Patterson Air Force Base, OH: Aerospace Medical Research Laboratory, Aerospace Medical Division, Air Force Systems Command, May 1976.

Nie, M. H., Hull, C. H., Jenkins, J. G., Steinbrenner, K., & Bent, D. H. Statistical package for the social sciences (SPSS) (2nd ed.). NY: McGraw-Hill, 1975.

Tenopyr, M. L. Physical proficiency tests as predictors of outside craft performance: Executive summary. Basking Ridge, NJ: Employment Research Group, American Telephone and Telegraph, March 1977.

Thorndike, R. L. Regression fallacies in the matched groups experiment. Psychometrika, 1942, 7, 85-102.

Tilton, J. W. Measurement of overlapping. Journal of Educational Psychology, 1937, 28, 656-662.

Wilmore, J. H. Alterations in strength, body composition, and anthropometric measurements consequent to a 10-week weight training program. Medicine and Science in Sports, 1974, 6, 133-138.

Wilmore, J. H. Body composition and strength development. Journal of Physical Education and Recreation (JOPER), 1975, 46, 38-40.

Wilmore, J. H., & Behnke, A. R. An anthropometric estimation of body density and lean body weight in young men. Journal of Applied Physiology, 1969, 27, 25-31.

Wilmore, J. H., & Behnke, A. R. An anthropometric estimation of body density and lean body weight in young women. American Journal of Clinical Nutrition, 1970, 23, 267-274.

Wolfe, L. A., Hodgson, J. L., Barlett, H. L., Nicholas, W. C., & Buskirk, E. R. Pulmonary function at rest and during exercise in uncomplicated obesity. The Research Quarterly, 1976, 47, 829-836.

APPENDIX

STRENGTH TEST ADMINISTRATION PROCEDURES AND INSTRUMENTATION

STRENGTH TEST ADMINISTRATION PROCEDURES AND INSTRUMENTATION

Sequence

To minimize fatigue and provide rest periods, tests were administered in the following order:

1. Static strength--handgrip, arm-pull, arm-lift.
2. Dynamic strength--bent-arm hang, push-up, sit-up, pull-up.
3. Anthropometric--height, weight, skinfold (4 sites).
4. Power--ergometer.

Directions for Test Procedures

Static Strength Tests

1. Handgrip (HGRIP). Use Smedley Hand Dynamometer (Lafayette Instruments Co. No. 78010). Adjust the handle for the subject's best grip. The second finger bone should be vertical across the handle. Let the subject test the dynamometer with an easy squeeze; readjust the handle if necessary. The subject should squeeze the handle with the arm hanging at his or her side (elbow may be flexed at an angle of about 10 degrees). The arm should not touch the body. Administer three trials for each hand, in the sequence L, R, L, R, L, R.

2. Arm-Pull (ARMPL). Use the Chatillon Push/Pull Gauge TCG-250 or TCG-500, attached to a pull bar (see Figure 1). With one hand holding the bar, the subject should brace the other hand on a vertical support without feet or toes touching the support. Administer three trials for each hand, in the sequence L, R, L, R, L, R. Say, "Easy pull, hold," for the subject to take up slack in the pull chain. Then say, "Steadily reach maximum pull," to avoid discrepantly high scores from the subject's snapping or jerking the handle. As soon as the maximum smooth pull is reached, say "relax."

3. Arm-Lift (ARMLF). Use the Chatillon Dynamometer WT-10-500 or Chatillon Push/Pull Gauge TCG-500, attached to a lift bar (see Figure 3). Set the pointer of the gauge to allow for the weight of the lift bar and chain. The subject should stand with feet slightly apart, straddling the cable and pulley. Say, "Hold the handle by the side bars, fists vertical, elbows at sides, with the handle bar not touching your abdomen." With the lower edge of the subject's forearms horizontal (down at an angle of about 10 degrees is permissible), adjust the chain length. Say, "Keep your back and legs straight. Keep your heels flat. Don't move your shoulders." Then say, "Take up the slack and apply slight tension. Easy lift, hold. Steadily reach maximum lift." As soon as maximum lift has been smoothly reached, say, "Relax." Administer three trials.

Dynamic Strength Tests

1. Sit-Up (SITUP) (to 30 seconds). Direct another person to hold the subject's ankles. The subject's knees should be slightly flexed, with about the space of one fist under the knees. Say, "Clasp your hands behind your neck, not behind your head. Both shoulder blades must touch the deck. Raise your trunk only to the vertical position." At signal "Start," the subject should rapidly do as many sit-ups as possible in 30 seconds. Count the number of sit-ups aloud. Say "no count" for any incorrect procedure.

2. Push-Up (PSHUP) (to 3 minutes). Say, "Lie flat on the deck, your hands beside your chest, fingers pointed forward, so that in raised position your forearms will be at right angles with the deck. Keep you feet together and your body straight. Only your chin and chest may touch the deck. Raise your body until your arms are straight (no elbow flex). Do not arch or sag your back." Count aloud the number of push-ups until there is no further progress for about 3 seconds. Say "no count" for any incorrect procedure.

3. Pull-Up (PULUP) (to 3 minutes). Provide a stool to assist the subject to reach the bar. The subject should hang from the bar, arms straight, palms facing the body. The subject should keep arms straight and bend knees to raise feet off the stool, so that the stool can be removed. Say, "At the signal, start. You will pull up until your chin is just over the bar, and then lower yourself until your arms are straight. Keep your legs hanging straight with no kicking or twisting." Direct another subject to prevent the performing subject's body from swaying or swinging. Count aloud the number of pull-ups until there is no further progress for about 3 seconds. Say "one-half" if (a) the subject's arms are not fully straight at the bottom of the pull-up, or (b) the subject's chin does not reach the top of the bar.

4. Bent-Arm Hang (BNTHG) (to 3 minutes). Assist the subject to assume the starting position on the bar, eyebrows level with the bar, palms facing away from the body. Say, "At the signal start, you will bend your knees slightly while I remove the stool; then let your legs hang straight, with no swinging, kicking, or twisting." The score is the number of seconds, up to a maximum of 180, that the subject does not lower eye level more than one inch below the bar.

Power Test

Ergometer (ERGOM) (to 30 seconds). Use Monark Rehab Trainer (Quinton Instrument Co. Model 880), with brake resistance set at 600 KPM, and with handle arms positioned vertically and set for the shortest length (4½ inches). Set the counter at zero. Before the test, advise the subject to atart at less than full effort to avoid rapid fatigue. Advise the subject that you will call out progress information: "Start," "15 seconds," "25 seconds, go to maximum effort," and "Stop" (at 30 seconds). At "start," subject should crank handles as rapidly as possible for 30 seconds. If necessary, advise the subject to speed up or slow down, depending on the subject's increasing fatigue during the test. The score is the number of revolutions on the counter at the end of 30 seconds.

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